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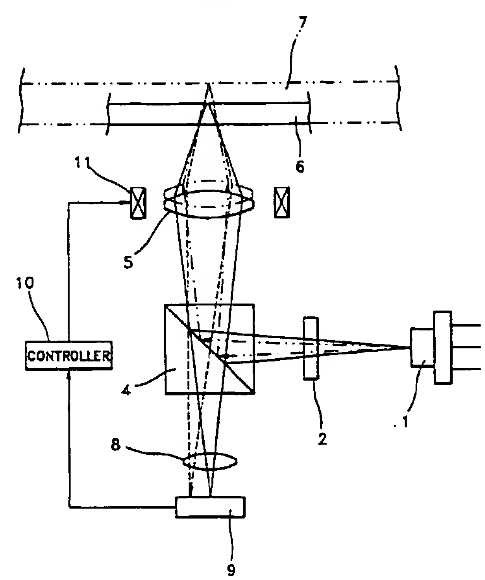
(54) Reproducing and recording optical pickup compatible for discs having different thicknesses

(57) A reproducing/recording optical pickup compatible for discs having different thicknesses includes a transparent plate (2) having a central portion formed with a diffraction grating pattern (3) for diffracting the light travelling from the light source (1) to the objective lens (5), and a transparent portion through which the light passes, and a photodetector (9) having first and second (16, 17) light receiving portions. The zero-order transmitted light and the passing light are focused using all regions of the aperture of the objective lens (5) with respect to a thin disc (6). The positive first-order diffracted light by the diffraction grating pattern (3) of the transparent plate (2) is focused onto a thick disc (7) by partial regions of the objective lens (5). Then, the reflected lights thereof are detected by the first and second light receiving portions (16, 17). Since signals for reproduction and servo for each disc are detected as the detection signals of the first and second light receiving portions (16, 17), stable servo and noiseless reproduction is possible, irrespective of the thickness of the disc used.

FIG.1



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Description

The present invention relates to an optical pickup for reading and writing information by scanning an optical recording medium with an optical beam, and more particularly, to a reproducing and recording optical pickup compatible for discs having different thicknesses.

An optical recording medium for storing data is mainly of the disc-type, for example, a compact disc. A disc is comprised of a plastics or glass substrate which is transparent to incident light having a predetermined thickness and a recording plane coated on the substrate, on which information is recorded. The light focused by an objective lens of an optical pickup is refracted on the substrate of the disc, lands on the recording plane and is then reflected from the recording plane to the optical pickup.

In order to increase the recording density of the disc, it is necessary to reduce the size of the light spot landing on the recording plane by as much as possible. The diameter of the spot is generally proportional to a numerical aperture (NA) of the objective lens and is inversely proportional to a wavelength of the light. Thus, in order to obtain a very small spot for high-density reproduction and recording, currently, it is common to use an objective lens having a large NA and a light source having a short wavelength. However, objective lenses having a large NA drastically increase the spot aberration on the recording plane when the disc is not directly perpendicular to the beam. Thus, for high-density discs, the tilt allowance of the disc should be controlled more precisely. Since the aberration is also proportional to the substrate thickness of the disc, the substrate is made thin so as to increase the tilt allowance of the high-density disc. Accordingly, as a high-density disc, a digital video disc having a substrate thickness of 0.6mm has come about, in lieu of the conventional compact disc having a substrate thickness of 1.2mm.

In optical reproduction and recording, compatibility between the compact disc and the digital video disc is an important factor from the standpoint of the user. However, if the disc thicknesses are different, spherical aberration is generated, which enlarges the spot formed on the recording plane of the disc. This in turn results in insufficient light intensity necessary for recording and deterioration of signals during reproduction. Thus, it is necessary for an optical pickup to read and write information with an aberration-corrected spot, that is, which is compatible to discs having different thicknesses.

As one such conventional compatible optical pickup, there is a well-known technology disclosed in the Japanese laid-open publication hei 7-98431, in which a hologram lens is installed in the receiving side of an objective lens, and aberration-corrected spots are formed respectively on the recording plane of disc having different thicknesses utilizing the difference between emitting angles of zero-order transmitted light and first-order diffracted light by the hologram lens. However, according to this technology, the diffraction efficiency of the hologram lens is 40% at most. Further, since the light emitted from the optical pickup passes through the hologram lens twice along the optical path, the amount of light finally received in the photodetector is noticeably reduced.

Also, U.S. Patent 5,281,797 by Tatsuno et al. teaches a technology of adjusting the numerical aperture (NA) of an objective lens by a plate having two apertures of different diameters, a diaphragm for use in a camera, or a liquid crystal device (LCD). In the case of employing the plate or diaphragm, complex devices are necessary for driving the same mechanically. In case of employing the LCD, the device is simply driven by electrical signals. However, in view of endurance and heat-resistance, the LCD cannot attain reliability for an extended period of time.

Also, two objective lenses optimized depending on the disc thickness may be alternatively used, which is not desirous, however, as the objective lenses are mechanically driven.

It is an aim of embodiments of the present invention to provide a reproducing and recording optical pickup compatible for discs having different thicknesses, having means for adjusting the numerical aperture (NA) of an objective lens without being mechanically and electrically driven in order to form light spots whose aberrations are corrected with respect to the discs having different thicknesses, and which can obtain a light efficiency higher than that of the conventional optical pickup adopting the hologram lens.

According to an aspect of the invention, there is provided an optical pickup having a light source, an objective lens for focusing the light generated from the light source onto a disc and a photodetector for detecting a signal by receiving the light reflected from the disc, for recording or reproducing information, comprising: a transparent plate having a central portion formed with a diffraction grating pattern for diffracting the light travelling from the light source to the objective lens, and a transparent portion through which the light passes, wherein a zero-order transmitted light separated by the diffraction grating pattern and the light pass through the transparent portion are focused onto a thin disc by the objective lens, and a positive first-order diffracted by the diffraction grating pattern is focused onto a thick disc by the objective lens.

Preferably, said diffraction grating pattern of said transparent plate is a serration-type.

A beam splitter may be provided between the light source and the objective lens for splitting the light path of incident light travelling from the light source toward the objective lens, wherein a transparent plate having a diffraction grating pattern is disposed between the light source and the beam splitter.

Said photodetector may have first and second light receiving portions for receiving light reflected from said thin and thick discs, respectively.

Said first and second light receiving portions of said photodetector may each be composed of four divided regions bisected horizontally and vertically, further comprise an astigmatism lens along the path of the light travelling toward said photodetector.

Further, the present invention may be constructed such that there is provided a separate diffraction grating between the objective lens and the transparent plate for diffracting the light transmitted via the transparent plate into a zero-order light and positive and negative first-order diffracted lights, wherein the photodetector includes first and second light receiving portions for receiving the reflected lights of the zero-order transmitted light being reflected from the discs having different thicknesses, respectively, and third and fourth light receiving portions for receiving the positive and negative first-order diffracted lights.

Said first and second light receiving portions of said photodetector may each be composed of four divided regions bisected horizontally and vertically, and further comprise an astigmatism lens along the path of the light travelling toward said photodetector.

For a better understanding of the invention, and to show how embodiments of the same may be carried into effect, reference will now be made, by way of example, to the accompanying diagrammatic drawings, in which:

Figure 1 is a schematic diagram illustrating the optical structure of a reproducing and recording optical pickup compatible for discs having different thicknesses according to an embodiment of the present invention;

Figure 2 is a profile showing a light path for the transparent plate having a diffraction grating pattern shown in Figure 1;

Figure 3 is a detailed plan view of the photodetector shown in Figure 1;

Figure 4 is a schematic diagram illustrating the optical structure of a reproducing and recording optical pickup compatible for discs having different thicknesses according to another embodiment of the present invention;

Figure 5 is a profile showing a light path for a diffraction grating shown in Figure 4; and

Figure 6 is a detailed plan view of the photodetector shown in Figure 4.

In Figure 1, reference numeral 1 denotes a light source, reference numeral 2 denotes a transparent plate having a diffraction grating pattern 3 (see Figure 2), reference numeral 4 denotes a beam splitter, reference numeral 5 denotes an objective lens, reference numeral 6 and 7 denote thin and thick discs, respectively, reference numeral 8 denotes an astigmatism lens, reference numeral 9 denotes a photodetector, reference numeral 10 denotes a controller, and reference numeral 11 denotes an actuator for an objective lens. Here, the two discs 6 and 7 have different thicknesses. For example, the high-density thin disc 6 is a 0.6mm thick digital video disc, and the thick disc 7 is a 1.2mm thick compact disc. As the light source 1, a laser diode for emitting a laser beam is employed. The light emitted from the light source 1 passes through the transparent plate 2, reflected by the beam splitter 4 and focused onto the discs 6 and 7 by the objective lens 5. The light reflected from the discs 6 and 7 passes back through the objective lens 5 and through the beam splitter 4, and is received in the photodetector 9 via the astigmatism lens 8. The photodetector 9 detects signals for reproducing the information recorded on the disc 6 (7) and signals indicative of focus and track positions of the objective lens 5 with respect to the respective disc 6 (7), to then transmit the same to the controller 10. The controller 10 operates the actuator 11 to adjust the focus and compensate for tracking errors of the objective lens 5 in accordance with the transmitted signals.

In the aforementioned configuration, the transparent plate 2 has a diffraction grating pattern 3 engraved in the center thereof, as shown in Figure 2. The light emitted from the light source 1 and passing through a central portion, i.e., the region where the diffraction grating pattern 3 is formed, is diffracted by the diffraction grating pattern 3 and a transparent portion, i.e., the region around the diffraction grating pattern 3 is transmitted through the regions other than the diffraction grating pattern 3. The diffraction grating pattern 3 of the transparent plate 2 diffracts the incident light into a zero-order transmitted light 14 and a positive first-order diffracted light 15. Here, the diffraction grating pattern 3 is manufactured as a serration-type, as shown in Figure 2 to increase light efficiency. The zero-order transmitted light 14 and the positive first-order diffracted light 15 can be separated by the serration-type diffraction grating pattern 3 such that the amount of the zero-order transmitted light 14 and the positive first-order diffracted light 15 are 40% of the original light intensity, respectively. At this time, the useless negative first-order diffracted light (not shown) can be reduced to less than 5%.

The zero-order transmitted light 14 travels along its original direction to then be focused onto the thin disc 6 by the objective lens 5, together with the light 13 passing through the far-axis portion. In other words, since the light is focused using all regions of the aperture of the objective lens 5 with respect to the thin disc 6, a very tiny spot can be formed on the thin disc 6. The positive first-order diffracted light 15 is also focused onto the thick disc 7 by the objective lens 5. At this time, by using a limited regions of the aperture of the objective lens 5, an aberration-corrected spot is formed on the thick disc 7. Here, the emitting angles of the zero-order transmitted light 14 and the light 13 of the far-axis portion 13 do

not change. Therefore, the very small spot formed on the thin disc 6 is formed along the optical axis of the objective lens 5. However, since the emitting angle of the positive first-order diffracted light 15 is slightly changed, the spot on the thick disc 7 is spaced slightly apart from the optical axis of the objective lens 5 (see Figure 1).

Figure 3 is a plan view of the photodetector 9 shown in Figure 1. The photodetector 9 is composed of a first light receiving portion 16 and a second light receiving portion 17. The first and second light receiving portions 16 and 17 are each divided into four regions A-D and E-H. The first light receiving portion 16 is formed at a position coinciding with the central axis of the objective lens 5 so as to receive light reflected from the thin disc 6, and the second light receiving portion 17 is formed next to the first light receiving portion 16 so as to receive light reflected from the thick disc 7. Therefore, when using the thin or thick discs 6 or 7, the respective reproduction signals and signals indicative of each focus and track positions are calculated from the first light receiving portion 16 and second light receiving portion 17 of the photodetector 9, respectively, as follows.

When using the thin disc 6:

$S1=S_a+S_b+S_c+S_d$... Reproduction signal
$S2=(S_a+S_c)-(S_b+S_d)$... Focus error signal
$S3=(S_a+S_b)-(S_c+S_d)$... Tracking error signal.

When using the thick disc 7:

$S4=S_e+S_f+S_g+S_h$... Reproduction signal
$S5=(S_e+S_g)-(S_f+S_h)$... Focus error signal
$S6=(S_e+S_f)-(S_g+S_h)$... Tracking error signal.

Here, S_a through S_h are signals output from the divided regions A through H, respectively.

The focus and tracking error signals are transmitted to the controller 10 (Figure 1), which in turn operates the actuator 11 so that the vertical and horizontal positions of the objective lens 5 are controlled according to the focus and tracking error signals.

Figure 4, in which like reference numerals shown in Figure 1 indicate like elements, illustrates the reproducing and recording optical pickup compatible for discs having different thicknesses according to another embodiment of the present invention, which is constructed to detect a track servo signal using three beams. In this embodiment, there is further provided a diffraction grating 18 between the transparent plate 2 and the beam splitter 4, and a photodetector 9' further includes third and fourth light receiving portions 19 and 20, as shown in Figure 6. Referring to Figure 5, the diffraction grating 18 is unevenly shaped and diffracts incident light into a zero-order transmitted light 21 and positive and negative first-order diffracted lights 22 and 23. Therefore, the objective lens 5 shown in Figure 4, focuses the zero-order transmitted light 21 and the positive and negative first-order diffracted lights 22 and 23 to thereby form three spots on the disc 6 (7). Also, referring to Figure 6, each reflected light of the zero-order transmitted light 21 is received in the first and second light receiving portions 16 and 17 of the photodetector 9' and each reflected light of the positive and negative first-order diffracted lights 22 and 23 is received in the third and fourth light receiving portions 19 and 20. The reproduction signals and focus error signals operate in the same manner as described above, and the track error signal S7 operates as follows:

$$S7=S_i-S_j$$

where S_i and S_j are detection signals of the third and fourth light receiving portions 19 and 20, respectively. In other words, according to this embodiment, irrespective of the thickness of the disc, the operation circuit can be commonly used in detecting tracking error signals for a track servo, thereby simplifying the circuitry and servo.

As described above, according to the present invention, in order to form each aberration-corrected spot on discs having different thicknesses, a transparent plate having a diffraction grating formed on a part thereof is employed, thereby providing a simplified and optically stable optical pickup, in contrast to the conventional optical pickup which drives a diaphragm. Also, the optical pickup according to the present invention has a higher light efficiency than the conventional one using a hologram lens. Particularly, according to the present invention, since the light reflected from the discs having different thicknesses is received separately in the first and second light receiving portions of the photodetector, the detection of the reproduction signals without interference from each other is possible. Also, the focus and tracking errors for the respective discs can be detected precisely, irrespective of the disc thickness, allowing attaining a stable operation.

The present invention is not limited to types of optical pickups or focus and track servo methods of an objective lens illustrated in the above and the drawings, but, on the contrary, is intended to cover various changes and modifications included within the scope of the appended claims.

The reader's attention is directed to all papers and documents which are filed concurrently with or previous to this specification in connection with this application and which are open to public inspection with this specification, and the contents of all such papers and documents are incorporated herein by reference.

All of the features disclosed in this specification (including any accompanying claims, abstract and drawings), and/or all of the steps of any method or process so disclosed, may be combined in any combination, except combinations where at least some of such features and/or steps are mutually exclusive.

Each feature disclosed in this specification (includ-

ing any accompanying claims, abstract and drawings), may be replaced by alternative features serving the same, equivalent or similar purpose, unless expressly stated otherwise. Thus, unless expressly stated otherwise, each feature disclosed is one example only of a generic series of equivalent or similar features.

The invention is not restricted to the details of the foregoing embodiment(s). The invention extends to any novel one, or any novel combination, of the features disclosed in this specification (including any accompanying claims, abstract and drawings), or to any novel one, or any novel combination, of the steps of any method or process so disclosed.

Claims

1. A reproducing/recording optical pickup compatible for discs having different thicknesses, having a light source (1), an objective lens (5) for focusing light generated from said light source (1) onto said discs (6, 7) and a photodetector (9) for detecting a signal by receiving the light reflected from a disc (6, 7), comprising:

   a transparent plate (2) having a central portion formed with a diffraction grating pattern (3) for diffracting the light travelling from said light source (1) to said objective lens (5), and a transparent portion through which the light passes,

   wherein a zero-order transmitted light separated by said diffraction grating pattern (3) and the light pass through said transparent portion are focused onto a thin disc (6) by said objective lens (5), and a positive first-order diffracted by said diffraction grating pattern (31) is focused onto a thick disc (7) by said objective lens (5).

2. A reproducing/recording optical pickup compatible for discs (6, 7) having different thicknesses, as claimed in claim 1, wherein said diffraction grating pattern (3) of said transparent plate (2) is a serration-type.

3. A reproducing/recording optical pickup compatible for discs having different thicknesses, as claimed in claim 1, further comprising a beam splitter (4) between said light source (1) and said objective lens (5) for splitting the light path of the incident light travelling from said light source (1) toward said objective lens (5), wherein said transparent plate (2) having said diffraction grating pattern (3) is disposed between said light source (1) and said beam splitter (4).

4. A reproducing/recording optical pickup compatible for discs having different thicknesses, as claimed in claim 1, wherein said photodetector (9) has first (16) and second (17) light receiving portions for receiving light reflected from said thin (6) and thick (7) discs, respectively.

5. A reproducing/recording optical pickup compatible for discs having different thicknesses, as claimed in claim 4, wherein said first and second light receiving portions (16, 17) of said photodetector (9) are each composed of four divided regions (A-D, E-H) bisected horizontally and vertically, and further comprising an astigmatism lens (8) along the path of the light travelling toward said photodetector (9).

6. A reproducing/recording optical pickup compatible for discs (6, 7) having different thicknesses, as claimed in claim 1, further comprising a diffraction grating (18) between said objective lens and said transparent plate (2) for diffracting the light transmitted via said transparent plate (2) into a zero-order transmitted light and positive and negative first-order diffracted lights, wherein said photodetector (9') includes first and second receiving portions (16, 17) for receiving reflected lights of said zero-order transmitted lights being reflected from said discs having different thicknesses, respectively, and third and fourth receiving units (19, 20) for receiving reflected lights of said positive and negative first-order diffracted lights.

7. A reproducing/recording optical pickup compatible for discs having different thicknesses, as claimed in claim 6, wherein said first and second light receiving portions (16, 17) of said photodetector (9') are each composed of each four divided regions (A-D, E-H) bisected horizontally and vertically, and further comprising an astigmatism (8) lens along the path of the light travelling toward said photodetector (9).

FIG.1

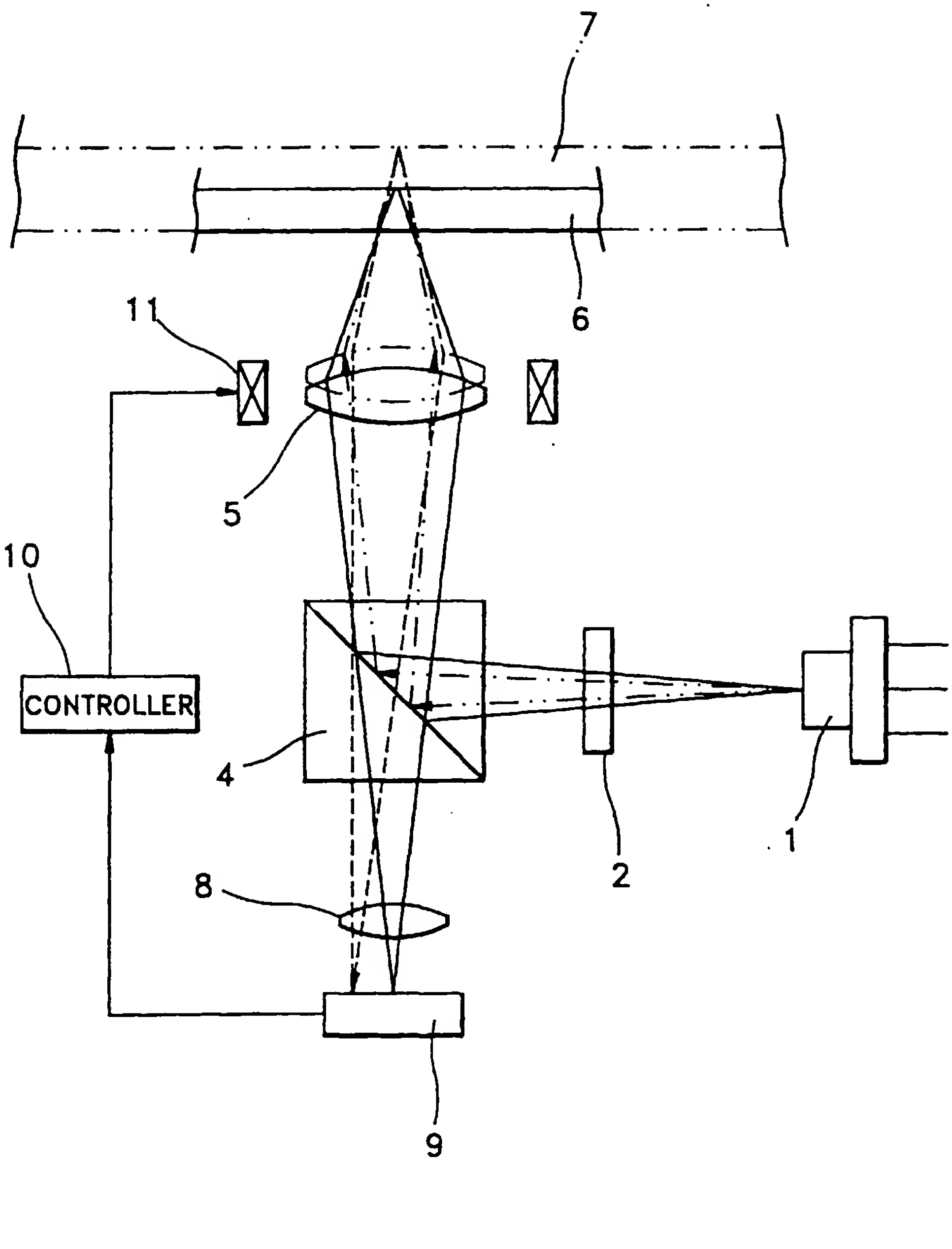


FIG.2

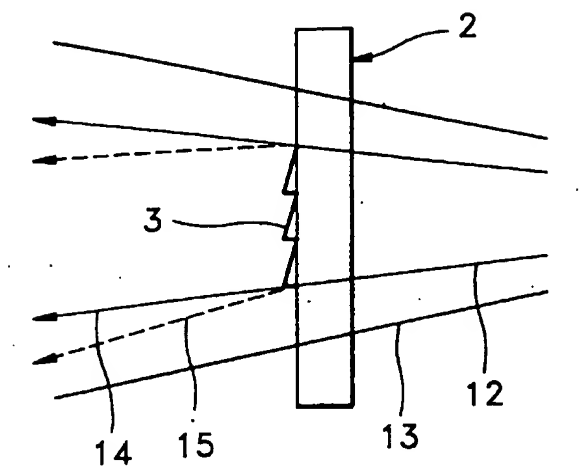


FIG.3

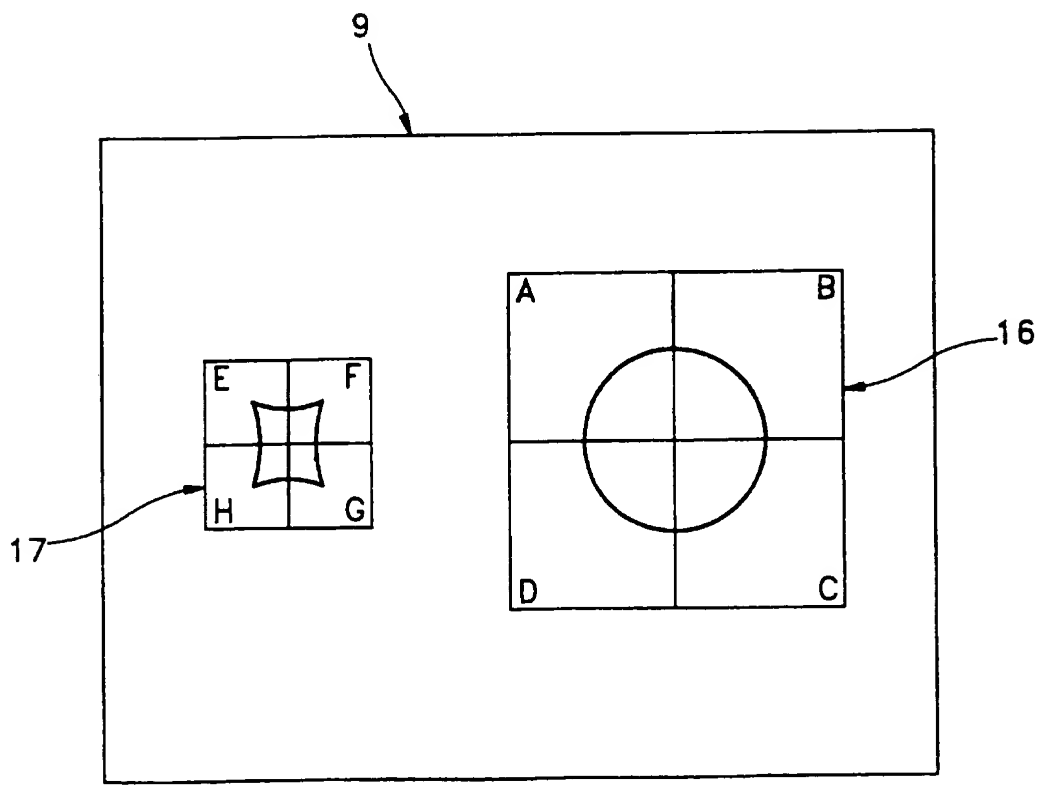


FIG.4

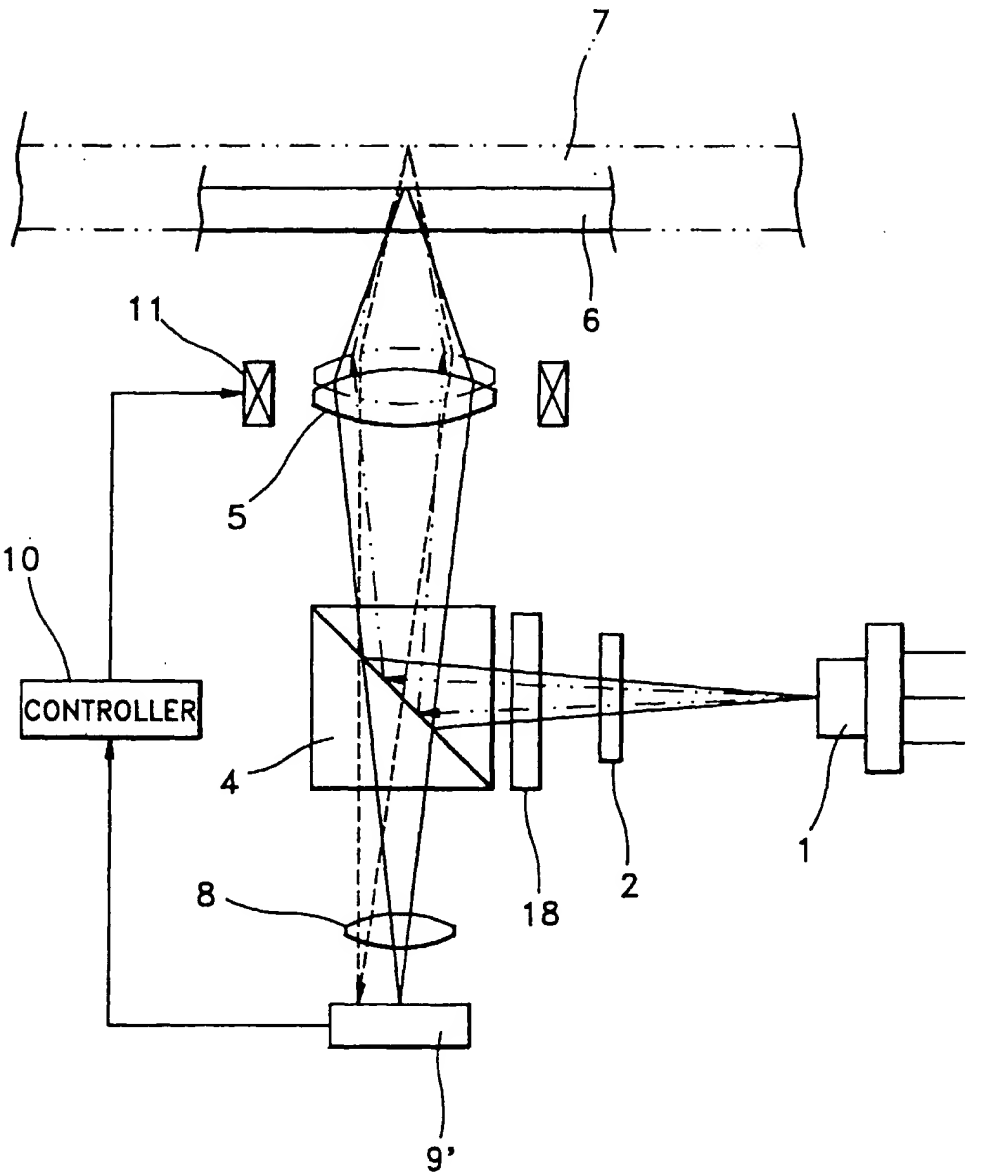


FIG.5

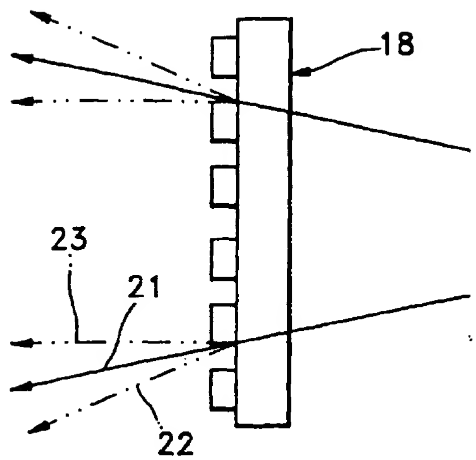
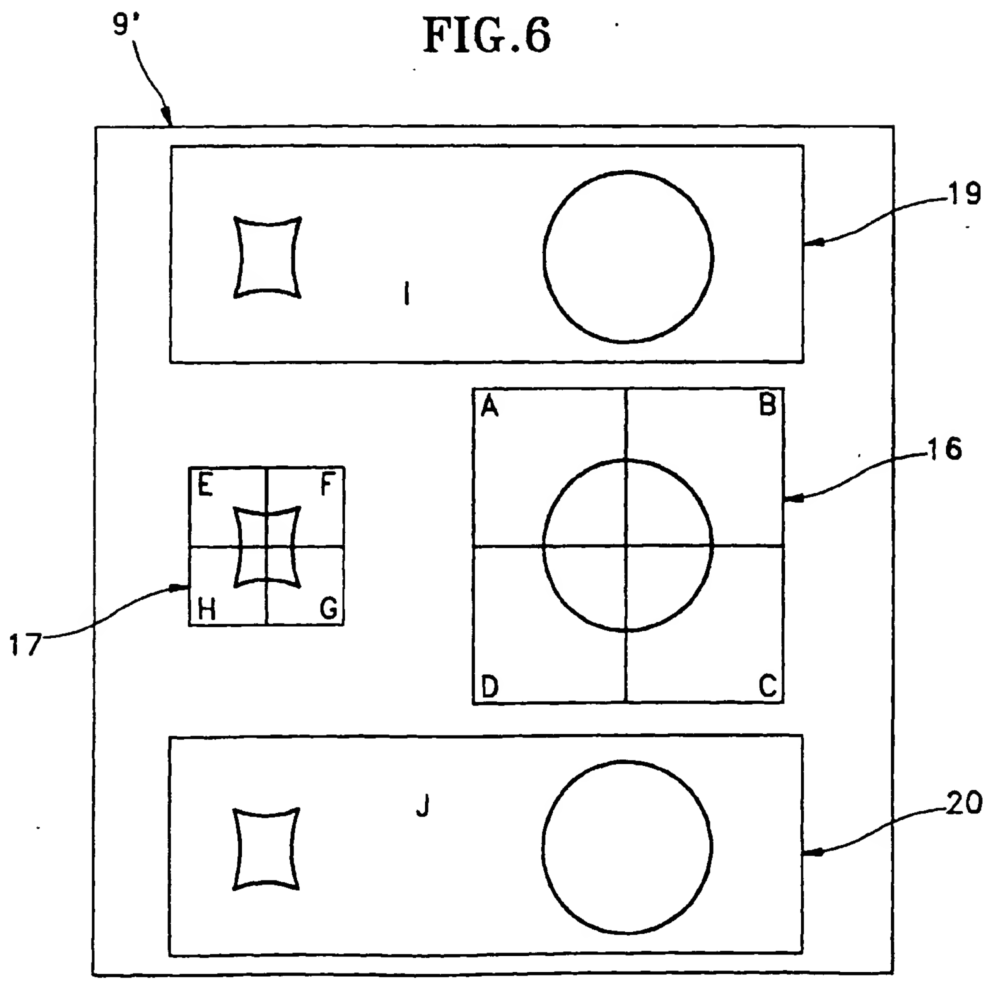


FIG.6



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EUROPEAN SEARCH REPORT

Application Number
EP 96 30 8733

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.6)
X	EP 0 610 055 A (MATSUSHITA ELECTRIC IND CO LTD) 10 August 1994 * column 31, line 26 - column 32, line 53; figures 4,5,8,28,29 *	1,2	G11B7/125 G11B7/135
A		3-7	
D	& JP 07 098 431 A -----		
			TECHNICAL FIELDS SEARCHED (Int.Cl.6)
			G11B

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	18 March 1997	Annibal, P

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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